CVM UNIVERSITY
Aegis: Charutar Vidya Mandal (Estd.1945)

FACULTY OF ENGINEERING & TECHNOLOGY

Effective from Academic Batch: 2020-21

Programme: **Bachelor of Engineering (Information Technology)**

Semester: **V**

Course Code: **102005602**

Course Title: **Introduction To Numerical Methods in Differential Equations**

Course Group: **Open Elective - I**

Course Objectives: This course is a under graduate-level course in numerical methods for ordinary and partial differential equations (ODE, PDE). It is required for all under graduate students in B.E/B. Tech. In this course, classical numerical methods for ODE and PDE problems, as well as properties of these methods, are studied using numerous examples. The course will provide basic fundamental knowledge and experience of work with numerical methods necessary for applied mathematicians and applied scientists.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Theory		J/V/P*		Total
Lecture	Tutorial	Practical		Internal	External	Internal	External	
2	2	0	3	40 / 14	60 / 21	NA	NA	100 / 35

* **J**: Jury; **V**: Viva; **P**: Practical

Detailed Syllabus:

Sr.	Contents	Hours
1	**First Order Ordinary Differential Equations: Initial Value Problems:** Some Important Classifications and Terms, Ordinary and Partial Differential Equations, Order and Degree of Differential Equations, Homogeneous and Non-homogeneous Differential Equations, Constant and Variable Coefficient Differential Equations, Linear and Nonlinear Differential Equations, General, Particular and Singular Solutions, Initial Value Problem (IVP) and Boundary Value Problem (BVP), Existence and Uniqueness of Solutions, Comparison of Analytical and Numerical Methods, Errors in Numerical Methods, Single Step and Multi Step Methods, Modified (or) Improved Euler Method (or) Heun Method, Runge–Kutta (RK) Methods, Milne Method (Milne Simpson Method), Order and Stability of Numerical Methods, Stability Analysis of IVP.	06
2	**Systems of First Order ODEs and Higher Order ODEs**: Initial and Boundary Value Problems, Euler Method, Runge–Kutta Fourth Order Method, Boundary Value Problem: Shooting Method, Finite Difference Approximations for Derivatives, First Order Derivatives, Second Order Derivatives.	08

3	**Partial Differential Equations: Finite Difference Methods:** Classification of Second-Order Quasi-Linear PDEs, Initial and Boundary Conditions , Finite Difference Approximations for Partial Derivatives, Parabolic Equation (1-dimensional Heat Conduction Equation), 1 Bender–Schmidt Explicit Scheme, Crank–Nicolson (CN) Scheme, General Implicit Scheme, Consistency, Convergence and Stability of Explicit and Crank–Nicolson Schemes, Consistency, Consistency of Explicit Scheme, Convergence and Order, Stability, Matrix Method for Stability of Explicit Scheme, Matrix Method for Stability of CN Scheme.	**08**
4	**2-Dimensional Heat Conduction Equation:** Explicit Scheme, Crank-Nicolson (CN) Scheme, Alternating Direction Implicit (ADI) Scheme Elliptic Equations Laplace Equation, Poisson Equation	**08**
5	**Fuzzy Classification:** Classification, Classification by Crisp and Fuzzy Equivalence Relations, Cluster Analysis, Cluster Validity, c −Means Clustering, Hard c −Means (HCM), Fuzzy c −Means (FCM), Classification Metric, Hardening the Fuzzy c −Partition	**05**
6	**Fuzzy Control Systems:** Control System Design Problem, Control (Decision) Surface, Assumptions in a Fuzzy Control System Design, Simple Fuzzy Logic Controllers, Examples of Fuzzy Control System Design, Aircraft Landing Control Problem	**05**
	Total	**40**

List of Practicals / Tutorials:

1	First order ordinary differential equations
2	Improved Euler Method (or) Heun Method, Runge–Kutta (RK) Methods, Milne Method
3	System of First order ODE
4	System of Higher order ODE
5	Finite Difference Methods 1
6	Finite Difference Methods 2
7	2-Dimensional Heat Conduction Equation
8	Elliptic Equations

Reference Books:

1	Numerical Methods Fundamentals and Applications, by Rajesh Kumar Gupta Cambridge University Press
2	Numerical Methods, by J. Douglas Faires Richard Burden BROOKS/COLE CENGAGE Learning
3	Finite Difference Methods for Ordinary and Partial Differential Equations Steady-State and Time-Dependent Problems, by Randall J. LeVeque Society for Industrial and Applied Mathematics
4	Numerical Methods for Differential Equations A Computational Approach, by John R. Dormand CRC Press
5	Finite Difference Schemes and Partial Differential Equations, by Strikwerda. Publisher: SIAM, 2007.

Supplementary learning material:

1	Lecture Note
2	Indian Institute of Technology, Kharagpur: Numerical Methods of Ordinary and Partial Differential Equations | Cosmo Learning Mathematics

Pedagogy:

- Direct classroom teaching
- Audio Visual presentations/demonstrations
- Assignments/Quiz
- Continuous assessment
- Interactive methods
- Industrial/ Field visits

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks in %						**R**: Remembering; **U**: Understanding; **A**: Applying; **N**: Analyzing; **E**: Evaluating; **C**: Creating
R	**U**	**A**	**N**	**E**	**C**	
20%	40%	30%	10%	---	---	

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcomes (CO):

Sr.	Course Outcome Statements	%weightage
CO-1	Student will be able identify some Important Classifications and Terms of Ordinary and Partial Differential Equations	**25**
CO-2	Formulate a selection of System of ODE describing physical phenomena, give a detailed account for the principal differences, strengths and weaknesses of commonly used numerical methods for ODE, discretize ODE in time and space for unequal intervals	**25**
CO-3	Formulate a selection of PDE describing physical phenomena, give a detailed account for the principal differences, strengths and weaknesses of commonly used numerical methods for PDE, discretize PDE in time and space	**25**
CO-4	Formulate common numerical solution methods for various PDE with associated boundary/ initial conditions	**25**

Curriculum Revision:	
Version:	1.0
Drafted on (Month-Year):	June-2020
Last Reviewed on (Month-Year):	-
Next Review on (Month-Year):	June-2025